AK

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 858 894 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
19.08.1998 Bulletin 1998/34

(51) Int Cl.^{6}: B41J 2/16, B41J 2/14

(21) Application number: 98101641.3

(22) Date of filing: 30.01.1998

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 31.01.1997 JP 19349/97
09.05.1997 JP 119546/97

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(54) Member having ultrafine groove, member for passage, method of manufacturing the same, ink jet printer head using the same, and ink jet printer head

(57) A member 10 having ultrafine groove of high density and high precision is obtained in a simple process.

On one side of a flat plate 11 made of ceramics, glass, silicone or the like, a partition wall 12 obtained by forming powder of ceramics, glass, silicone or the like by a molding die having a recess is bonded and integrated, and a member 10 having ultrafine groove is composed.

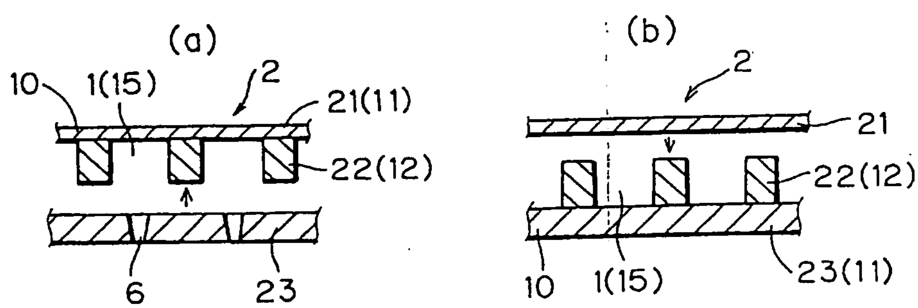
A member for passage 110 of high density and high precision is obtained in a simple process.

On one side of a flat plate 111 made of ceramics, glass, silicone or the like, a partition wall 112 obtained by forming powder of ceramics, glass, silicone or the like by a molding die having a recess is bonded and integrated, and a member for passage 110 is composed by forming a passage 113 between partition walls 112.

In an ink jet printer head comprising plural ink chambers 201, an ejection port 206 communicating with the ink chambers 201, and a diaphragm 221 for applying a pressure to the ink chambers 201, the displacement of a piezoelectric element 201 is favorably transmitted to the diaphragm 221, and the manufacturing process is simplified.

The diaphragm 221 is formed of conductive inorganic material, and a piezoelectric element 203 is bonded to the diaphragm 201, and a driving electrode 204 is formed on this piezoelectric element 203.

FIG.3



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Description

BACKGROUND OF THE INVENTION

The present invention relates to a member having ultrafine groove used in displacement control element, motor, relay, switch, shutter, printer head, pump, fan, ink jet printer, and others, and an ink jet printer head using the same.

Recently, in the field of optics and precision processing, a displacement control element capable of adjusting the optical path length or position in the sub-micron order is demanded, and to meet such demand, various actuators are devised including, for example, those utilizing piezoelectric material and others utilizing static electricity.

More lately, in particular, for use in ink jet printer head, a small-sized actuator is proposed, in which a ceramic green sheet is formed, air vents forming ink chambers are formed by a die, and by laminating and baking, using a part thereof as diaphragm, a piezoelectric drive section is formed on the surface (see Japanese Laid-open Patent No. 4-12678).

The structure of this ink jet printer head is as shown in Fig. 7, in which a nozzle plate 23 forming a nozzle 6, a partition wall 22 forming ink chambers 1 or ink passages, and a diaphragm 21 are fabricated of ceramic green sheet, and laminated and integrated, thereby obtaining a head substrate 2 having ink chambers 1 and nozzles 6 and ink passages (not shown) communicating therewith, and an electrode 4a, a piezoelectric element 3, and an electrode 4b are formed on the diaphragm 21 of the head substrate 2.

By applying a voltage between the electrodes 4a and 4b, the piezoelectric element 3 is deformed, and this displacement is transmitted to the ink chambers 1 through the diaphragm 21, so that the ink in the ink chambers 1 can be ejected from the nozzles 6.

The ink jet printer head is required to have higher density and higher precision as the product is reduced in size. For example, the width of the partition wall 22 forming the head substrate 2 is demanded to be fabricated in the order of scores of microns.

By contrast, in the manufacturing process of the ink jet printer head shown in Fig. 7, when fabricating the partition wall 22 forming the head substrate 2, by blanking a ceramic green sheet by a die, the ink chambers 1 and ink passages were formed, and hence it was extremely difficult to manufacture in such small size at high density and high precision. That is, when blanking the green sheet by the die, the sheet was torn, or the position was deviated when laminating the nozzle plate 23 and diaphragm 21, and it was impossible to manufacture at high density and high precision.

It was also hard and costly to manufacture the die used in such blanking in small size and at high precision.

The invention is devised in the light of the above problems, and it is hence an object thereof to fabricate the member having ultrafine groove used in the ink jet printer head or the like easily at high precision and high density.

The invention is therefore characterized by bonding a partition wall obtained by forming powder of ceramics, glass, silicone or the like by a molding die with a recess on one side of a flat plate of ceramics, glass, silicone or the like, integrating, and composing a member having ultrafine groove.

The invention is also characterized by applying a mixture of powder of ceramics, glass, silicone or the like, and a binder composed of solvent and organic additive to fill in a molding die having a recess for partition wall, bonding this mixture to a flat plate of ceramics, glass, silicone or the like, integrating, and manufacturing a member having ultrafine groove.

The invention is further characterized by forming the flat plate as a diaphragm, comprising a piezoelectric element for driving this diaphragm and an electrode for applying a voltage to the piezoelectric element, and bonding a nozzle plate to form the ultrafine groove as ink chamber, thereby composing an ink jet printer head.

That is, a mixture for partition wall material is applied into a prepared molding die having a recess for partition wall, and this mixture is bonded and integrated to one side of a flat plate, so that the shape of the molding die is directly transferred onto the flat plate. Therefore, when the molding die is preliminarily fabricated at high density and high precision, the partition wall can be easily formed at high density and high precision.

Herein, the procedure of bonding and integrating the partition wall and flat plate comprises steps of filling the molding die having the recess with mixture, solidifying tightly on the flat plate, and parting and baking, or the steps of filling the molding die with the mixture, solidifying, parting, contacting with the flat plate, and baking, or the steps of filling the molding die with the mixture, solidifying, parting, baking, and contacting to or thermally bonding to the flat plate. Besides, the general glass and ceramics bonding method may be employed.

The invention relates to a member for passage having tiny passages of liquid for use in ink jet head or small-sized pump, and its manufacturing method, and more particularly to an ink jet printer head using the same.

Today, along with the advancement of the multimedia, the demand for personal computers is increasing steadily, and the printer which is one of the recording media of personal computer is required to have higher density and high definition in its performance. In particular, the ink jet system, introduced to replace the existing dot system, has been improved to print more quietly, at higher definition and higher density, and it is now occupying the throne of printers.

The ink jet system is proposed in various methods, such as the method of discharging ink drops from the nozzle

by making use of a piezoelectric material, and the method of generating bubbles in the ink by heat, and discharging the ink drops. In these methods, commonly, the ink is fed into the printer head, the ink is supplied through passage, and the ink is discharged from the ink discharge port.

Such ink jet printer head by thermal method is shown in Fig. 8, in which a flat plate 111 has plural partition walls 112, and a substrate 120 is bonded to a member 110 for passage forming a passage 113 between partition walls 112, thereby covering each passage 113. One end of each passage 113 is a discharge port 114, and other end communicates with an ink chamber 116 having an ink feed hole 115. Moreover, at a position corresponding to each passage 113 of the substrate 120, a heating element 121 and an electrode 122 for energizing it are disposed.

Moreover, as shown in Fig. 9, with the passage 113 filled with the ink 130, when the heating element 121 is energized to generate heat, bubbles 132 are generated in the ink 130, and by the force of the expansion of volume of these bubbles 132, ink drops 131 are discharged from the discharge port 113.

Incidentally, higher definition and higher density are demanded in the ink jet printers recently, and in the passage members 110 for composing the ink jet printer head 101, the width of the partition wall 112 and passage 113 is demanded to be as narrow as scores of microns.

To manufacture the passage member 110 having such ultrafine passages 113, various methods have been proposed, including a method of forming a masking in the portion of the partition wall 112 on the flat plate 111, and processing grooves as passages 113 by sand blasting, a method of forming partition walls 112 by repeating screen printing on the flat plate 111, and a method of applying a photosensitive resin in the portion of the partition walls 112 on the flat plate 111, and forming grooves as passages 113 by photolithography.

However, in the sand blasting method, since the passages 113 are formed while digging grooves by blowing powder, it is necessary to keep constant the powder blowing force and angle, and it was difficult to process the inner surface of the passages 113 in a specified shape at high precision. In the screen printing method, it is necessary to print many times, and the partition walls 112 were deformed. In the photolithography method, a slight difference was caused in the degree of right angle and depth of the partition walls due to light illumination angle, time or other condition, and it was hard to form the passages 113 at high precision.

Yet, in the passage members 110 obtained in these manufacturing methods, the inner surface of the passages 113 was not smooth.

In any method, hence, it was hard to form the passages 113 at high precision, and a smooth inner surface was not obtained. As a result, the ink flow was disturbed in the passages 113, and fluctuations were likely to occur in the ink discharge volume, discharge pressure, and response.

The invention is devised in the light of the above problems, and it is hence an object thereof to manufacture the passage members used in the ink jet printer head or the like easily at high precision and high density.

The invention is therefore characterized by bonding plural partition walls obtained by forming powder of ceramics, glass, silicone or the like by a molding die with a recess on one side of a flat plate of ceramics, glass, silicone or the like, integrating by arraying in one direction, and composing passage members having passages between partition walls.

The invention is also characterized by applying a mixture of powder of ceramics, glass, silicone or the like, and a binder composed of solvent and organic additive to fill in a molding die having plural recesses for partition walls, bonding this mixture to one side of a flat plate of ceramics, glass, silicone or the like, integrating by arraying in one direction, and thereby manufacturing passage members.

The invention is further characterized by composing an ink jet printer head by covering the passages by bonding a substrate to the upper surface of the partition walls in the passage members, comprising a heating element in each passage, and generating bubbles in the ink in the passages by the heat of the heating elements, thereby discharging the ink.

That is, in the invention, a mixture for partition wall material is filled into a prepared molding die having recesses for partition walls, and this mixture is bonded and integrated to one side of flat plates to obtain partition walls, so that the shape of the molding die is directly transferred onto the flat plates. Therefore, when the molding die is preliminarily fabricated at high density and high precision, the partition walls can be easily formed at high density and high precision.

Moreover, by forming the surface of the molding die smoothly beforehand, the surface of the formed partition walls is also smooth, and passages having smooth inner surface are obtained.

Herein, the procedure of bonding and integrating the partition walls and flat plates comprises steps of filling the molding die having the recesses with mixture, solidifying tightly on the flat plates, and parting and baking, or the steps of filling the molding die with the mixture, solidifying, parting, contacting with the flat plate, and baking, or the steps of filling the molding die with the mixture, solidifying, parting, baking, and contacting to or thermally bonding to the flat plate. Besides, the general glass and ceramics bonding method may be employed.

Moreover, the invention relates to an ink jet printer head used in an ink jet printer.

The ink jet printer is a printer for printing by ejecting ink from the head, and it is widely used recently owing to low noise and high printing speed.

The structure of the ink jet printer head is as shown in Fig. 12, in which a head substrate 202 comprises plural ink chambers 201 and ejection ports 206, and piezoelectric elements 203 are bonded to the positions corresponding to the ink chambers 201. The head substrate 202 is composed by mutually bonding a plate 223 forming ejection ports 206, a plate 222 forming ink chambers 201, and a diaphragm 221, and a piezoelectric element 203 is bonded on this diaphragm 221 through a lower electrode 205, and a driving electrode 204 is formed thereon.

By deforming the piezoelectric element 203 by applying a voltage between the lower electrode 205 and driving electrode 204, the diaphragm 221 is deflected, and the pressure in the ink chambers 201 is elevated so that the ink may be ejected from the ejection ports 206.

The conventional head substrate 202 and others were made of metal materials, but recently, it has been proposed to use ceramics (see Japanese Laid-open Patent No. 6-40030 and Japanese Laid-open Patent No. 6-218929).

For example, the head substrate 202 is formed of ceramics mainly composed of any one of aluminum oxide, magnesium oxide, and zirconia oxide, and the lower electrode 205, piezoelectric element 203 such as PZT, and driving electrode 204 are formed on the diaphragm 221 to compose the ink jet printer head, so that the reliability may be kept high for a long period of use.

When manufacturing such ceramics-made ink jet printer head, on the green sheet mainly composed of at least one of aluminum oxide, magnesium oxide and zirconium oxide, plates 222, 223 are fabricated by blanking with a die in the positions corresponding to the ink chambers 201 and ink passages, and they are laminated with one green sheet as diaphragm 221, and bonded by thermocompression, and the head substrate 202 is fabricated by baking at temperature of about 1400°C corresponding to the baking temperature of ceramics.

Afterwards, on the diaphragm 221 corresponding to each ink chamber 201, metal paste is applied by screen printing as lower electrode 205, and then, for example, a PZT material is formed as piezoelectric element 203 by thick film forming method, baked at about 1200°C, and a driving electrode 204 is formed thereon, thereby producing an ink jet printer head as shown in Fig. 12.

In such ceramics-made ink jet printer head, however, after fabricating the head substrate 202 by integrally baking the plates 222, 223 and diaphragm 221, it is necessary to form and bake the lower electrode 205, piezoelectric element 203 and driving electrode 204 individually on the head substrate 202, and it requires a total of three or more steps of baking process, and the manufacturing process is complicated and the cost is increased.

Moreover, to adjust to the position of the ink chambers 201, it requires a total of three steps of positioning for the lower electrode 205, piezoelectric element 203 and driving electrode 204, 50 positioning is difficult, and when these positions are deviated from the specified position, the designed performance may not be exhibited.

Further, since the lower electrode 205 is disposed between the piezoelectric element 203 and diaphragm 221, deformation of the piezoelectric element 203 is hardly transmitted to the diaphragm 221, which may lead to lowering of driving efficiency.

On the other hand, in the case of a metal-made ink jet printer head, not only the corrosion resistance is inferior, but also the response of the diaphragm to the piezoelectric element is poor because a bonding material must be placed between the diaphragm and piezoelectric element in order to bond them.

It is hence an object of the invention to present an ink jet printer head that can be manufactured easily and is excellent in driving characteristic.

The invention relates to an ink jet printer head comprising plural ink chambers, ejection ports communicating with the ink chambers, and a diaphragm for applying a pressure to the ink chambers, in which the diaphragm is formed of a voltage-withstanding inorganic material, a piezoelectric element is bonded to the diaphragm, and a driving electrode is formed on the piezoelectric element.

It is also a feature of the invention that the conductive inorganic material for composing the diaphragm has a volume specific resistance of $1\times 10^{-1}\ \Omega\cdot$cm or less.

Moreover, the conductive inorganic material for composing the diaphragm of the invention is composed of any one of conductive ceramics, ceramics or glass having conductive agent, and thermet.

In the ink jet printer head of the invention, the diaphragm is composed of conductive inorganic material, and this diaphragm is used also as the lower electrode, so that the lower electrode is not needed. That is, by applying a driving voltage between the diaphragm and driving electrode, the piezoelectric element can be deformed.

Accordingly, the manufacturing process of the lower electrode can be omitted, and the manufacturing process can be simplified, and moreover the deformation of the piezoelectric element can be transmitted to the diaphragm efficiently.

Still more, by forming the diaphragm by inorganic material such as ceramics and glass, the corrosion resistance can be enhanced, and the piezoelectric element can be bonded directly without resort to bonding agent, so that the deformation of the piezoelectric element can be transmitted to the diaphragm efficiently.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view showing a member having ultrafine groove of the invention.

Fig. 2 shows other embodiment of the invention, in which (a) is a perspective view, and (b) is a sectional view.

Fig. 3 is a sectional view showing the process of manufacturing a head substrate of an ink jet printer head, by using the member having ultrafine groove of the invention.

Fig. 4 (a), (b) are sectional views showing a different embodiment of the invention.

Fig. 5 (a), (b) are sectional views for explaining a manufacturing method of a member having ultrafine groove of the invention.

Fig. 6 is a sectional view showing an application example of the member having ultrafine groove of the invention.

Fig. 7 is a partially cut-away perspective sectional view showing a structure of an ink jet printer head.

Fig. 8 is a schematic perspective exploded view of an ink jet printer head using passage members of the invention.

Fig. 9 is a longitudinal sectional view near the discharge port of the ink jet printer head in Fig. 8.

Fig. 10 (a), (b) are sectional views for explaining a manufacturing method of passage members of the invention.

Fig. 11 is a partially cut-away perspective view showing an ink jet printer head of the invention.

Fig. 12 is a sectional view showing a conventional ink jet printer head.

EMBODIMENTS

Embodiments of the invention are described below.

A member 10 having ultrafine groove is shown in Fig. 1, in which a partition wall 12 made of one of glass, ceramics, silicone and others is bonded and integrated to one side of a flat plate 11 made of one of glass, ceramics, silicone and others, and one ultrafine groove 15 is formed between partition walls 12. In a member 10 having ultrafine groove shown in Fig. 2, on the other hand, multiple partition walls 12 made of one of glass, ceramics, silicone and others are bonded and integrated to one side of a flat plate 11 made of one of glass, ceramics, silicone and others, and plural ultrafine grooves 15 are formed between partition walls 12.

As specifically described below, the partition walls 12 are formed by using a molding die, and bonded and integrated to the flat plate 11, and are hence formed at high density and high precision.

By using such member 10 having ultrafine groove, a head substrate 2 of ink jet printer head as shown in Fig. 7 can be fabricated. That is, as shown in Fig. 3 (a), the flat plate 11 is formed as a diaphragm 21, the partition walls 12 as partition walls 22, and a separately fabricated nozzle plate 23 having nozzles 6 is bonded, and therefore the ultrafine grooves 15 are formed as ink chambers 1, and the head substrate 2 is obtained.

Or, as shown in Fig. 3 (b), forming nozzles 6 in the flat plate 11, a nozzle plate 23 is formed, the partition walls 12 are formed as partition walls 22, and a separately fabricated diaphragm 21 is bonded, and therefore the ultrafine grooves 15 are formed as ink chambers 1, and the head substrate 2 is obtained.

At this time, since the partition walls 22 (12) are formed at high density and high precision, by using this head substrate 2, an ink jet printer head of high density and high precision can be obtained.

Alternatively, as shown in Fig. 3 (a), when the flat plate 11 of the member 10 having ultrafine groove is formed as a diaphragm, a piezoelectric element can be formed on the flat plate 11. That is, as shown in Fig. 4 (a), by laminating the electrode 14 and piezoelectric element 13 on the flat plate 11 either in a single layer or in plural layers, when a voltage is applied between the electrodes 14, the piezoelectric element 13 is deformed, and the flat plate 11 is displaced, so that it can act as diaphragm.

Moreover, as shown in Fig. 4 (b), the electrode 14 and piezoelectric element 13 can be laminated on the upper and lower side of the flat plate 11 either in a single layer or in plural layers.

And although not shown in drawing, a partition wall 12 formed of a piezoelectric material, an electrode can comprise on the upper and lower side of a partition wall 12 or on both side of a partition wall 12. In this case, a partition wall 12 is displaced by applying a voltage to a partition wall 12 by an electrode, said partition wall 12 can be used for a diaphram.

In this way, when the flat plate 11 is provided with the piezoelectric element 13 and electrode 14, or an electrode 14 is provided with the patition wall 12 formed of a piezoelectric material, this member 10 having ultrafine groove is used as a member for actuator, and hence not limited to the ink jet printer head alone, it can be used in the displacement control element, motor, relay, switch shutter, printer head, pump, fan, etc.

The manufacturing method of the member 10 having ultrafine groove of the invention is described below.

First, as shown in Fig. 5 (a), a molding die 19 having a recess 19a conforming to the shape of the partition walls 12 is prepared, and the recess 19a of the molding die 19 is filled with a mixture 12' of powder of ceramics, glass, silicone or the like, and a binder composed of solvent and organic additive as a material for composing the partition walls 12.

On the other hand, a flat plate 11 composed of ceramics, glass, silicone or the like is separately prepared, and the molding of the mixture 12' is bonded and integrated to this flat plate 11, thereby forming the partition walls 12, and more specifically the manufacturing procedure is as follows.

The flat plate 11 is pressed and adhered to the surface of the mixture 12' filling up the molding die 19, and the mixture 12' is solidified by curing by reaction or by drying. Then, as shown in Fig. 5 (b), by parting the molding die 19,

the partition wall 12 made of the molding of the mixture 12' is transferred on the substrate 11. Finally, the entire piece is removed of binder, and baked and integrated simultaneously, so that the member 10 having ultrafine groove as shown in Fig. 1 and Fig. 2 is manufactured.

In other method, after solidifying the mixture 12' filling up the molding die 19 by reaction curing or drying, it is parted from the molding die 19, and the molding of the mixture 12' is affixed to the flat plate 11. Finally, the entire piece is removed of binder, and baked and integrated at the same time, thereby obtaining the member 10 having ultrafine groove.

In a different method, after solidifying the mixture 12' filling up the molding die 19 by reaction curing or drying, it is parted from the molding die 19, and removed of the binder, and this molding is adhered to the flat plate 11.

Finally, the entire piece is simultaneously baked and integrated, thereby obtaining the member 10 having ultrafine groove.

Alternatively, after solidifying the mixture 12' filling up the molding die 19 by reaction curing or drying, it is parted from the molding die 19, and removed of the binder, and baked, and the obtained sinter is bonded to the flat plate 11 by adhering, thermal compression, or simultaneous baking, thereby obtaining the member 10 having ultrafine groove.

That is, the molding of the mixture 12' may be bonded to the flat plate 11 at any stage of the both members in unbaked state, binder removed state, or sintered state.

According such manufacturing method of the invention, the partition walls 12 can be formed easily, and hence the manufacturing process may be extremely simplified. What is more, since the partition walls 12 and their space are transferred from the shape of the recess 19a of the molding die 19, the specified partition walls 12 can be formed easily by processing the recess 19a precisely according to the specified shape.

As other application example of the invention, as shown in Fig. 6, by laminating, bonding and integrating member 10 having plural ultrafine grooves, a honeycomb structure having each ultrafine grooves 15 as penetration hole is obtained, and it can be used in ultrafine filter or the like. In addition, the member 10 having ultrafine grooves of the invention can be applied in various fields.

Herein, the ceramics powers usable for forming the flat plate 11 and partition wall 12 include alumina (Al_2O_3), zirconia (ZrO_2), other oxide-type ceramics, silicon nitride (Si_3N_4), aluminum nitride (AlN), silicon carbide (SiC), other non-oxide ceramics, apatite ($Ca_5(PO_4)_3(F, C1, OH)$), and others, and these ceramics powders may be combined with a specific amount of various sintering aids.

The usable sintering aids include silica (SiO_2), calcia (CaO), yttria (Y_2O_3), magnesia (Mg), and others for alumina powder, yttria (Y_2O_3), cerium (Ce), dysprosium (Dy), ytterbium (Yb), and other rare earth element oxides for zirconia powder, yttria (Y_2O_3), alumina (Al_2O_3) and others for silicon nitride powder, oxide of element of periodic table group 3a (RE_2O_3) and others for aluminum nitride powder, and boron (B), carbon (C) and others for silicon carbide powder, which may be added by a specified amount individually.

As the glass powder for forming the flat plate 11 and partition wall 12, various glass materials mainly composed of silicate and containing at least one of lead (Pb), sulfur (S), selenium (Se), alum, and others may be used.

Moreover, the flat plate 11 and partition wall 12 may be also formed from the silicone powder. Or the flat plate 11 and partition wall 12 may be formed from a compound powder of various materials, or other powder having similar characteristic as specified above.

The particle size of the powder of ceramics, glass, silicone and others is preferably scores of microns to sub-micron, and more specifically 0.2 to 10 microns, or preferably in a range of 0.2 to 5 microns.

As the organic additive to be added to these powders of ceramics, glass, or silicone, examples include urea resin, melamine resin, phenol resin, epoxy resin, unsaturated polyester resin, alkyd resin, urethane resin, ebonite, silicate polysiloxane, and others. Means for curing these organic additives by reaction may include heat curing, ultraviolet ray irradiation curing, X-ray irradiation curing, etc. From the standpoint of working efficiency and equipment, heat curing is optimum, and in particular, the unsaturated polyester resin is preferred from the viewpoint of pot life.

The content of the organic additive must be controlled so that the viscosity may not be too high in order to maintain the flowability and moldability of the mixture of powder of ceramics, glass, silicone or the like and the sintering aids, and when curing, on the other hand, a sufficient shape retaining property is desired. From such viewpoint, the content of the organic additive is preferably 0.5 part by weight or more in 100 parts by weight of powder of ceramics, glass, silicone or the like, and also from the viewpoint of shrinking of the molding by curing, it should be more preferably 35 parts by weight or less, and in particular, considering the shrinking when baking, it should be most preferably in a range of 1 to 15 parts by weight.

The solvent to be added in the mixture 12' is not particularly limited as far as it is compatible with the organic additives, and usable examples include toluene, xylene, benzene, ester phthalate and other aromatic solvents, hexanol, octanol, decanol, oxy alcohol and other higher alcohols, and ester acetate, glycerides and other esters.

In particular, ester phthalate and oxyl alcohol are preferably used, and two or more kinds of solvents may be used in order to evaporate the solvents slowly.

The content of the solvent is required to be 0.1 part by weight or more in 100 parts by weight of the powder of

ceramics, glass, silicone or the like in order to maintain the shape retaining property of the molding from the viewpoint of molding performance, is more preferably 35 parts by weight or less in order to lower the viscosity of the mixture of the powder of ceramics, glass, silicone or the like and organic additive, and most preferably 1 to 15 parts by weight in consideration of shrinkage when drying and baking.

The molding die 19 in the invention is not particularly limited in material as far as it is free from problem when curing the organic additive, and for example, metal, resin or rubber may be used, and if necessary, surface coating or surface treatment may be applied to enhance the parting performance or prevent abrasion.

The flat plate 11 is an unbaked green sheet or a sinter of ceramics, glass, silicone, or the like, and, for example, by using various ceramic green sheets, various glass substrates, ceramic substrates, or the like, the same material as the partition wall 12 or a material similar in the coefficient of thermal expansion is used. As the glass substrate, for example, soda lime glass, or relatively inexpensive glass dispersing inorganic filler for enhancing its distortion point may be used.

Moreover, in order to enhance the adhesion for compression bonding of the mixture 12' and flat plate 11, various coupling agents may be used such as silane coupling agent, titanate coupling agent, and aluminate coupling agent may be used, and the silane coupling agent is particularly preferred among them because the reactivity is high.

For compression bonding of the mixture 12' and flat plate 11, it is preferred to use an apparatus of static water pressure from the viewpoint of applying a uniform pressure, and as the pressurizing condition, the pressure should be in a range not to deform the molding die 19, and this pressure range varies with the strength of the molding die 19, and for example, when the molding die 19 made of silicone rubber is used, it is preferred to apply a pressure of about 100 g/cm^2.

In the mixture 12', in order to enhance the dispersion of the ceramics or glass powder, it may be also blended with, for example, polyethylene glycol ether, alkyl sulfonate, polycarbonate, alkyl ammonium salt, and other surface active agent, and the content thereof is preferred to be 0.05 to 5 parts by weight in 100 parts by weight of ceramics or glass powder from the viewpoint of enhancement of dispersion and pyrolysis.

The binder in the mixture 12' may be blended with curing catalyst known as curing reaction promoter or polymerization initiator. As the curing catalyst, organic peroxide or azo compound may be used, and examples include ketone peroxide, diacyl peroxide, peroxy ketal, peroxy ester, hydroperoxide, peroxy carbonate, t-butyl peroxy-2-ethyl hexanoate, bis (4-t-butyl cyclo hexyl) peroxy dicarbonate, dicumyl peroxide, other organic peroxides, azo bis, isobutyl nitrile, and other azo compound.

The piezoelectric element 13 is composed of a material which is deformed when a voltage is applied from the electrode 14, and piezoelectric ceramics mainly composed at least one of lead titanate-zirconate (PZT series), lead magnesium niobate (PMN series), lead nickel niobate (PNN series), lead manganese niobate, and lead titanate may be used.

Moreover, the electrodes 14 for driving disposed at both sides of the piezoelectric element 13 are not particularly defined as far as a conductor withstanding the baking temperature is used, and, for example, metal alone, alloy, or mixture of ceramics or glass and alloy with metal may be used. In particular, it is preferred to use at least one of platinum, palladium, rhodium, silver-palladium, silver-platinum, platinum-palladium, gold, silver, tungsten, and molybdenum.

Embodiment 1

The member 10 having ultrafine groove of the invention shown in Fig. 2 was experimentally fabricated.

The ceramics powder for forming the partition wall 12 was mainly composed of alumina (Al_2O_3), zirconia (ZrO_2), silicon nitride (Si_3N_4), and aluminum nitride (AlN) with mean particle size of 0.2 to 5 microns, and was blended with known baking aids mentioned above as required. In 100 parts by weight of these ceramic powders, the binder composition as shown in Table 1 was added and mixed, and the ceramics forming composition was prepared, and the mixture 12' was obtained. The kinds of the binder composition shown in Table 1 are as shown in Table 2.

[Table 1]

No.	Ceramic powder principal ingredient	Binder composition						Remarks
		Solvent		Organic additive		Other additive		
		Kind	Added parts by weight	Kind	Added parts by weight	Kind	Added parts by weight	
1	①	①	10	②	15	Dispersant	2	Ester phosphate
2	①	②	10	①	15	-	-	
3	①	②	10	②	15	Dispersant	2	Ester phosphate
4	①	②	10	②	20	Dispersant	2	Ester phosphate
5	②	②	10	②	15	Dispersant	2	Dodecylpolyethylene glycol
6	③	②	15	②	15	-	-	
7	④	②	10	②	15	Dispersant	2	Dodecylpolyethylene glycol

[Table 2]

	Symbol	Substance name
Ceramic powder principal ingredient	①	Alumina
	②	Zirconia
	③	Silicon nitride
	④	Aluminum nitride
Solvent	①	Diethyl phthalate
	②	Octanol
Organic additive	①	Epoxy resin
	②	Unsaturated polyester

After vacuum defoaming of thus obtained mixture 12', it was injected to fill up the recess 19a of the molding die 19 made of silicone resin as shown in Fig. 5 (a).

Then, on the surface of the mixture 12' filling up the molding die 19, a flat plate 11 of same ceramic sinter as the mixture 12' was applied, and this flat plate 11 was put in a heating oven, together with the molding die 19, while pressurizing at 100 g/cm^2, and heated and cured by holding for 45 minutes at temperature of 100°C.

After completion of curing, as shown in Fig. 5 (b), the partition wall 12 contacting with the flat plate 11 was parted from the molding die 19, and this molding was dried for 5 hours at 120°C, and was held in nitrogen atmosphere for 3 hours at 250°C, and was heated to 500°C for 12 hours to remove binder. Afterwards, the piece mainly composed of alumina was held in the atmosphere for 2 hours at 1600°C; the piece mainly composed of zirconia, in the atmosphere for 2 hours at 1450°C; the piece mainly composed of silicon nitride, in nitrogen atmosphere for 10 hours at 1650°C, and the piece mainly composed of aluminum nitride, in nitrogen atmosphere for 3 hours at 1800°C, and the member 10 having ultrafine groove of the invention shown in Fig. 2 was obtained by baking and integrating.

As comparative examples, a ceramic green sheet mainly composed of zirconia were prepared, and laminated by blanking the recess by the die, and baked and integrated, and members 10 having ultrafine groove of similar shape were prepared. The thickness of the ceramic green sheet was 100 microns (No. 8 in Table 3) and 40 microns (No. 9 in Table 3).

In these embodiments of the invention and comparative examples, results of observation of the shape of partition walls 12 are shown in Table 3.

As known from the results, in comparative example No. 8, although the thickness of the green sheet is greater than the width the partition wall 12 and the strength of the partition wall 12 is sufficient, it was deformed by the force when blanking with the die. In comparative example No. 9, since the green sheet is thin, the force when blanking with

the die is small, but it was easily deformed same as in No. 8. Still worse, in these comparative examples, a step was formed in the partition wall 12 due to deviation of position when laminating. Incidentally, the limit of the width of the partition wall 12 was 70 microns, and the yield was low.

By contrast, in Nos. 1 to 7 of the invention, such problems were not found, and the width of the partition wall 12 could be formed at less than 70 microns, and the shape was not deformed and the precision was high.

[Table 3]

No.	Shape of partition wall	Width of partition wall
1	Excellent	70 microns or more
2	Excellent	70 microns or more
3	Excellent	70 microns or more
4	Excellent	70 microns or more
5	Excellent	70 microns or more
6	Excellent	70 microns or more
7	Excellent	70 microns or more
* 8	Step and deformation found	80 microns
* 9	Step and deformation found	70 microns

* Comparative example

In the embodiment, the molding die 19 was filled with the mixture 12', and the flat plate 11 was pressed to heat and cure, but, instead, by parting and baking after filling the molding die 19 with the mixture 12' and heating and curing, it may be adhered to the flat plate and integrated. In short, in bonding of the partition wall 12 and flat plate 11, both may be done before baking, one before baking and other after baking, or both after baking. Anyway, the flat plate 11 and partition wall 12 are preferred to be closer in baking temperature and coefficient of thermal expansion.

The material for the flat plate 11 and partition wall 12 is not limited to the ceramics mentioned above, but same effects were confirmed by using other ceramics, various types of glass, silicon, etc.

Embodiment 2

Selecting No. 5 from embodiment 1, the electrode 14 was applied on the upper surface of the flat plate 11 of the member 10 having ultrafine groove fabricated therefrom, and the piezoelectric element 13 made of PZT was laminated, and the electrode 14 was further applied, and baked at 1000 to 1300°C, thereby obtaining a member for actuator used in ink jet printer head and the like.

After polarization process, a voltage was applied to drive, and the flat plate 11 was displaced, and a favorable driving state was obtained. Moreover, as shown in Fig. 4 (a), same effects were obtained by laminating plural piezoelectric elements 13 as shown in Fig. 4 (a).

Moreover, as shown in Fig. 4 (b), on both sides of the flat plate 11 of the member 10 having ultrafine groove, the electrode 14 and piezoelectric element 13 were laminated, and driving test was conducted similarly, and favorable driving was confirmed.

As mentioned above, according to the invention, by bonding and integrating a partition wall formed by forming powder of ceramics, glass, silicone or the like on one side of a flat plate made of ceramics, glass, silicone or the like, by using a molding die having a recess, the member having ultrafine groove of high density and high precision can be obtained in a simple process.

Also according to the invention, by manufacturing a member having ultrafine recess from the process for applying a mixture of powder of ceramics, glass, silicone or the like and a binder composed of solvent and organic additive into a molding die having a recess for partition, and bonding and integrating this mixture to a flat plate made of ceramics, glass, silicone or the like, the shape of the molding die is directly transferred onto the flat plate, and therefore by preparing the molding die at high density and high precision, the partition wall can be easily formed at high density and high precision.

Therefore, according to the invention, the member having ultrafine groove of high density and high precision can be manufactured in an extremely simple process, and hence it may be preferably used in application of ink jet printer head or the like.

An embodiment of applying the passage member of the invention in the ink jet printer head is described below.

As shown in Fig. 8, on a flat plate 11 made of one of glass, ceramics, silicone and others, plural partition walls 112 made of one of glass, ceramics, silicone and others is bonded and integrated, and passage members 110 are composed, forming passages 113 between partition walls 112. In the passage member 110, a substrate 120 is bonded to

the upper surface of each partition wall 112 to cover the passage 113, and one end of each passage 113 is a discharge port 114, and other end communicates with an ink chamber 116 having an ink feed hole 115, thereby composing an ink jet printer head 101. At the position corresponding to each passage 113 of the substrate 120, a heating element 121 and an electrode 122 for energizing it are provided.

Further, as shown in Fig. 9, by generating heat by energizing the heating element 121 with the passage 113 filled with ink 130 through the ink chamber 116, bubbles 132 are generated in the ink 130, and ink drops 131 are discharged from the discharge port 114 by the force when the bubbles 132 expand by volume.

As specifically described below, after forming the partition wall 112 by using the molding die, it is bonded and integrated to the flat plate 111, and therefore it can be formed at high density and high precision, and the ink jet printer head 101 of extremely high performance is realized.

A manufacturing method of the passage member 110 of the invention is described below.

First, as shown in Fig. 10 (a), a molding die 119 having a recess 119a suited to the shape of the partition wall 112 is prepared, and the recess 119a of the molding die 119 is filled with a mixture 12' of powder of ceramics, glass, silicone or the like and a binder of solvent and organic additive as the material for forming the partition wall 112.

On the other hand, a flat plate 111 made of ceramics, glass, silicone or the like is prepared separately, and the molding of the mixture 12' is bonded and integrated to this flat plate 111, and the partition wall 112 is formed, and it is specifically manufactured as described below.

On the surface of the mixture 112' filling up the molding die 119, the flat plate 111 is pressed and adhered, and the mixture 112' is solidified by reaction curing or drying. Then, as shown upside down in Fig. 10 (b), by parting the molding die 119, the partition wall 112 made of the molding of the mixture 112' is transferred on the flat plate 111. Finally, removing the binder from the whole structure, the passage member 110 is manufactured by baking and integrating simultaneously as shown in Fig. 8.

In other method, the mixture 112' filling the molding die 119 is solidified by reaction curing or drying, and parted from the molding die 119, and the molding of the mixture 112' is affixed to the flat plate 111. Finally, removing the binder from the whole structure, and baking and integrating simultaneously, the member 110 having ultrafine groove is obtained.

In a different method, the mixture 112' filling the molding die 119 is solidified by reaction curing or drying, and parted from the molding die 119, and after removing the binder, the molding is adhered to the flat plate 111. Finally, the whole structure is baked and integrated simultaneously, and the member 110 having ultrafine groove is obtained.

Alternatively, the mixture 112' filling the molding die 119 is solidified by reaction curing or drying, and parted from the molding die 119, removed the binder and baked, and this sinter is bonded to the flat plate 111 by adhesion, thermal compression bonding, or simultaneous baking, so that the member 110 having ultrafine groove is obtained.

That is, the molding of the mixture 112' may be bonded to the flat plate 111 in any stage of both members being in unbaked state, binder removed state, or sinter state.

According to such manufacturing methods of the invention, since the partition walls 112 can be formed easily, the manufacturing process can be simplified extremely. Moreover, the partition walls 112 and their space of passage 113 are formed by transfer of the shape of the recess 119a of the molding die 119, and therefore the specified partition walls 112 can be formed easily only by processing the recess 119a precisely in a specified shape.

Besides, the surface roughness of the passage member 113 obtained in this way is exactly same as the surface roughness of the molding die 119. Therefore, when the surface roughness (R_{max}) of the molding die 119 is small preliminarily, the surface roughness (R_{max}) of the obtained passage member 113 may be 0.01 to 0.8 micron, so that the ink 130 may be supplied smoothly. Herein, the surface roughness (R_{max}) of the passage member 113 is defined within 0.01 to 0.8 micron because it is extremely difficult to process within 0.01 micron, and if exceeding 0.8 micron, the flow of the ink 130 is disturbed, and the discharge amount and response tend to fluctuate.

Moreover, in an example in Fig. 10, the side surface of the partition wall 112 is vertical to the flat plate 111, but the side surface may be also formed in a slope or curvature so that the partition wall 112 may be gradually reduced in thickness.

Herein, the ceramics powder for forming the flat plate 111 and partition wall 112 may include alumina (Al_2O_3), zirconia (ZrO_2), other oxide-type ceramics, silicon nitride (Si_3N_4), aluminum nitride (AlN), silicon carbide (SiC), other non-oxide type ceramics, apatite ($Ca_5(PO_4)_3$(F, C1, OH)), and others, and these ceramics powders may be combined with a specific amount of various sintering aids.

The usable sintering aids include silica (SiO_2), calcia (CaO), yttria (Y_2O_3), magnesia (MgO), and others for alumina powder, yttria (Y_2O_3), cerium (Ce), dysprosium (Dy), ytterbium (Yb), and other rare earth element oxides for zirconia powder, yttria (Y_2O_3), alumina (Al_2O_3) and others for silicon nitride powder, oxide of element of periodic table group 3a (RE_2O_3) and others for aluminum nitride powder, and boron (B), carbon (C) and others for silicon carbide powder, which may be added by a specified amount individually.

As the glass powder for forming the flat plate 111 and partition wall 112, various glass materials mainly composed of silicate and containing at least one of lead (Pb), sulfur (S), selenium (Se), alum, and others may be used.

Moreover, the flat plate 111 and partition wall 112 may be also formed from the silicone powder. Or the flat plate 111 and partition wall 112 may be formed from a compound powder of various materials, or other powder having similar characteristic as specified above.

The particle size of the powder of ceramics, glass, silicone and others is preferably scores of microns to sub-micron, and more specifically 0.2 to 10 microns, or preferably in a range of 0.2 to 5 microns.

As the organic additive to be added to these powders of ceramics, glass, or silicone, examples include urea resin, melamine resin, phenol resin, epoxy resin, unsaturated polyester resin, alkyd resin, urethane resin, ebonite, silicate polysiloxane, and others. Means for curing these organic additives by reaction may include heat curing, ultraviolet ray irradiation curing, X-ray irradiation curing, etc. From the standpoint of working efficiency and equipment, heat curing is optimum, and in particular, the unsaturated polyester resin is preferred from the viewpoint of pot life.

The content of the organic additive must be controlled so that the viscosity may not be too high in order to maintain the flowability and moldability of the mixture of powder of ceramics, glass, silicone or the like and the sintering aids, and when curing, on the other hand, a sufficient shape retaining property is desired. From such viewpoint, the content of the organic additive is preferably 0.5 part by weight or more in 100 parts by weight of powder of ceramics, glass, silicone or the like, and also from the viewpoint of shrinking of the molding by curing, it should be more preferably 35 parts by weight or less, and in particular, considering the shrinking when baking, it should be most preferably in a range of 1 to 15 parts by weight.

The solvent to be added in the mixture 112' is not particularly limited as far as it is compatible with the organic additives, and usable examples include toluene, xylene, benzene, ester phthalate and other aromatic solvents, hexanol, octanol, decanol, oxy alcohol and other higher alcohols, and ester acetate, glycerides and other esters.

In particular, ester phthalate and oxyl alcohol are preferably used, and two or more kinds of solvents may be used in order to evaporate the solvents slowly.

The content of the solvent is required to be 0.1 part by weight or more in 100 parts by weight of the powder of ceramics, glass, silicone or the like in order to maintain the shape retaining property of the molding from the viewpoint of molding performance, is more preferably 35 parts by weight or less in order to lower the viscosity of the mixture of the powder of ceramics, glass, silicone or the like and organic additive, and most preferably 1 to 15 parts by weight in consideration of shrinkage when drying and baking.

The molding die 119 in the invention is not particularly limited in material as far as it is free from problem when curing the organic additive, and for example, metal, resin or rubber may be used, and if necessary, surface coating or surface treatment may be applied to enhance the parting performance or prevent abrasion.

The flat plate 111 is an unbaked green sheet or a sinter of ceramics, glass, silicone, or the like, and, for example, by using various ceramic green sheets, various glass substrates, ceramic substrates, or the like, the same material as the partition wall 112 or a material similar in the coefficient of thermal expansion is used. As the glass substrate, for example, soda lime glass, or relatively inexpensive glass dispersing inorganic filler for enhancing its distortion point may be used.

Moreover, in order to enhance the adhesion for compression bonding of the mixture 112' and flat plate 111, various coupling agents may be used such as silane coupling agent, titanate coupling agent, and aluminate coupling agent may be used, and the silane coupling agent is particularly preferred among them because the reactivity is high.

For compression bonding of the mixture 112' and flat plate 111, it is preferred to use an apparatus of static water pressure from the viewpoint of applying a uniform pressure, and as the pressurizing condition, the pressure should be in a range not to deform the molding die 119, and this pressure range varies with the strength of the molding die 119, and for example, when the molding die 119 made of silicone rubber is used, it is preferred to apply a pressure of about 100 g/cm^2.

In the mixture 112', in order to enhance the dispersion of the ceramics or glass powder, it may be also blended with, for example, polyethylene glycol ether, alkyl sulfonate, polycarbonate, alkyl ammonium salt, and other surface active agent, and the content thereof is preferred to be 0.05 to 5 parts by weight in 100 parts by weight of ceramics or glass powder from the viewpoint of enhancement of dispersion and pyrolysis.

The binder in the mixture 112' may be blended with curing catalyst known as curing reaction promoter or polymerization initiator. As the curing catalyst, organic peroxide or azo compound may be used, and examples include ketone peroxide, diacyl peroxide, peroxy ketal, peroxy ester, hydroperoxide, peroxy carbonate, t-butyl peroxy-2-ethyl hexanoate, bis (4-t-butyl cyclo hexyl) peroxy dicarbonate, dicumyl peroxide, other organic peroxides, azo bis, isobutyl nitrile, and other azo compound.

The material for the substrate 120 for composing the ink jet printer head 101 shown in Fig. 8 is, same as the passage member 110, ceramics, glass, silicone or the like, and this substrate 120 and passage member 110 are bonded by using resin or low melting glass, or by heat.

The electrode 122 formed on the substrate 120 is composed of metal such as W, Mo, Ag, Ag-Pd, Pd, Au, Ni, Cr, or two or more thereof may be combined. In the embodiment, the heating element 121 is provided at the substrate 120 side, but the heating element 121 may be also provided at the passage member 110 side. Or a plurality of passage

members 110 may be laminated.

In the embodiment, having the heating element 121 in the passage 113, an example of applying in the ink jet printer head 101 of the system for generating bubbles by heat is disclosed, but the passage member of the invention may be also applied in the passage of ink in the piezoelectric type ink jet printer head, in the passage of ink in the compound type ink jet printer head of foam generating type and piezoelectric type, and in the passage in other methods.

The passage member of the invention is not limited to the ink jet printer head, but may be used in various applications of vacuum suction members by small pump, air pump, etc.

Embodiment 3

The passage member 110 of the invention shown in Fig. 8 was experimentally fabricated.

The ceramic powder for forming the partition wall 112 mainly comprises alumina (Al_2O_3), zirconia (ZrO_2), silicon nitride (Si_3N_4), and aluminum nitride (AlN) with mean particle size of 0.2 to 5 microns, and known sintering aids were added as required. In 100 parts by weight of these ceramic powders, the binder compositions shown in Table 4 were added, and ceramic forming compositions were prepared as mixture 112'. The kinds of the binder compositions shown in Table 4 are as shown in Table 5.

[Table 4]

No	Ceramic powder principal ingredient	Binder composition						Remarks
		Solvent		Organic additive		Other additive		
		Kind	Added parts by weight	Kind	Added parts by weight	Kind	Added parts by weight	
1	①	①	10	②	15	Dispersant	2	Ester phosphate
2	①	②	10	①	15	-	-	
3	①	②	10	②	15	Dispersant	2	Ester phosphate
4	①	②	10	②	20	Dispersant	2	Ester phosphate
5	②	②	10	②	15	Dispersant	2	Dodecylpolyethylene glycol
6	③	②	15	②	15	-	-	
7	④	②	10	②	15	Dispersant	2	Dodecylpolyethylene glycol

[Table 5]

	Symbol	Substance name
Ceramic powder principal ingredient	①	Alumina
	②	Zirconia
	③	Silicon nitride
	④	Aluminum nitride
Solvent	①	Diethyl phthalate
	②	Octanol
Organic additive	①	Epoxy resin
	②	Unsaturated polyester

After vacuum defoaming of thus obtained mixture 112', it was injected to fill up the recess 119a of the molding die 119 made of silicone resin as shown in Fig. 10 (a).

Then, on the surface of the mixture 112' filling up the molding die 119, a flat plate 111 of same ceramic sinter as

the mixture 112' was applied, and this flat plate 111 was put in a heating oven, together with the molding die 119, while pressurizing at 100 g/cm^2, and heated and cured by holding for 45 minutes at temperature of 100°C.

After completion of curing, as shown in Fig. 10 (b), the partition wall 112 contacting with the flat plate 111 was parted from the molding die 119, and this molding was dried for 5 hours at 120°C, and was held in nitrogen atmosphere for 3 hours at 250°C, and was heated to 500°C for 12 hours to remove binder. Afterwards, the piece mainly composed of alumina was held in the atmosphere for 2 hours at 1600°C; the piece mainly composed of zirconia, in the atmosphere for 2 hours at 1450°C; the piece mainly composed of silicon nitride, in nitrogen atmosphere for 10 hours at 1650°C, and the piece mainly composed of aluminum nitride, in nitrogen atmosphere for 3 hours at 1800°C, and the passage member 110 of the invention shown in Fig. 8 was obtained by baking and integrating.

The width of the partition wall 112 of the passage member 110 was 50 microns, and the width of the passage 113 was 100 microns.

On the other hand, the substrate 120 was formed by using the same material as the passage member 110, and the heating element 121 was placed on the substrate 120, and it was bonded to the passage member 110 by glass, thereby fabricating an ink jet printer head 101.

This ink jet printer head 101 was mounted on an actual printer, and tested, and it was confirmed to be usable satisfactorily.

Embodiment 4

In this embodiment of the invention, using the material of No. 3 in Table 4, the molding die 119 differing in surface roughness was used, and the passage members 119 differing in surface roughness were prepared.

As comparative example, in the same material and dimensions, passage members were prepared by sand blasting method and screen printing method.

Using thus obtained passage members 110, ink jet printer heads 101 were manufactured as mentioned above, and tested in actual printers. The ink discharge ejection force (ink flying distance), uniformity of ink volume, and response were evaluated.

The results are summarized in Table 6, in which the characteristics are known to be very high when the surface roughness (R_{max}) is 0.8 micron or less in the passage members of the invention.

[Table 6]

	No.	Manufacturing method	Surface roughness (R_{max})	Ejection force	Uniformity	Response
Invention	1	Transfer by molding die	0.1 micron	◎	◎	◎
	2	Transfer by molding die	0.3 micron	◎	◎	○
	3	Transfer by molding die	0.8 micron	○	○	○
	4	Transfer by molding die	1.0 micron	Δ	Δ	Δ
	5	Transfer by molding die	1.5 micron	Δ	×	×
Comparison	6	Sand blasting	0.8 micron or more	○	○	Δ
	7	Screen printing	1.0 micron or more	○	Δ	Δ
Evaluation: ◎: Excellent, ○: Good, Δ: Unstable, ×: Poor						

The material for the flat plate 111 and partition wall 112 is not limited to the ceramics mentioned above, but same effects were obtained by using other ceramics, various types of glass or silicone.

As mentioned above, according to the invention, by bonding and integrating the partition wall made by forming powder of ceramics, glass, silicone or the like on one side of a flat plate made of ceramics, glass, silicone or the like by a molding die having a recess, and forming a passage between partition walls, the passage member of high density and high precision can be obtained in a simple process.

Also according to the invention, by manufacturing a passage member from the process for applying a mixture of powder of ceramics, glass, silicone or the like and a binder composed of solvent and organic additive into a molding die having a recess for partition, and bonding and integrating this mixture to a flat plate made of ceramics, glass, silicone or the like, the shape of the molding die is directly transferred onto the flat plate, and therefore by preparing

the molding die at high density and high precision, the partition wall can be easily formed at high density and high precision.

Therefore, according to the invention, the passage member of high density and high precision can be manufactured in an extremely simple process, and hence it may be preferably used in application of ink jet printer head or the like.

Referring now to the drawings, an embodiment of the invention is described below.

An ink jet printer head of the invention is composed, as shown in Fig. 11, by bonding a piezoelectric element 203 to a head substrate 202 having plural ink chambers 201 and an ejection port 206. The head substrate 202 is composed by mutually bonding a plate 223 forming the ejection port 206, a plate 222 forming the plural ink chambers 201, and a diaphragm 221, and the piezoelectric element 203 is directly bonded to the outside of the diaphragm 221 corresponding to each ink chamber 201, and a driving electrode 204 is formed thereon.

Herein, since the diaphragm 221 is formed of a conductive inorganic material, this diaphragm 221 may be used also as lower electrode. That is, by applying a constant voltage to the diaphragm 221, and applying a driving voltage to the driving electrode 204 on each piezoelectric element 203, the piezoelectric element 203 is deformed to deflect the diaphragm 221, and the pressure in the ink chambers 201 is raised, thereby ejecting the ink from the ejection port 206.

At this time, since the piezoelectric element 203 is directly bonded to the diaphragm 221, the deformation of the piezoelectric element 203 may be favorably transmitted to the diaphragm 221.

It is a feature of the invention that the conductive inorganic material is used as the diaphragm 221, and this conductive inorganic material should be a material of which volume specific resistance is $10^{-1}\ \Omega \cdot cm$ or less. In a material of which volume specific resistance exceeds $10^{-1}\ \Omega \cdot cm$, heat is generated when a voltage is applied, and the ink ejection performance is not stabilized.

As the conductive inorganic material for composing the diaphragm 221, conductive ceramics, or ceramics, glass or thermet containing conductive agent may be used.

Herein, conductive ceramics are ceramics having own conductivity, and, for example, ceramics having perovskite crystal structure explained in the formula

$$(LaA)\ (B)\ O_3$$

where

A: element of periodic table group 2a, such as Ma, Ca, Sr, Ba

B: one or more element selected from the group consisting of elements such as Mn, Co, Ni, and elements of periodic table groups 3a, 4a such as La, Ce, Zr, Y

may be used. Such ceramics having perovskite crystal structure are obtained by forming and baking the material powder in the above composition, and they are conductive ceramics having the volume specific resistance of $10^{-1}\ \Omega \cdot cm$ or less. Specifically, using ceramics such as La-Sr-MnO_3, La-Ca-MnO_3, or La-Ca-CrO_3, for example, ceramics expressed as $La_{0.2}\ Ca_{0.8}\ MnO_3$ may be used.

Ceramics or glass containing conductive agent is intrinsically insulating ceramics or glass, being provided with conductivity by containing conductive agent. For example, being mainly composed of ZrO_2, a material containing at least one metal oxide out of NiO, MnO_2, Fe_2O_3, Cr_2O_3, and CoO as conductive agent may be used. More specifically, ceramics comprising 30 to 60 wt.% of ZrO_2 containing stabilizing agent, and 70 to 40 wt.% of conductive agent such as NiO may be used after baking in oxidizing atmosphere. Besides, mainly composed of Al_2O_3, SiC, Si_3N_4, etc., ceramics containing a specific conductive agent and adjusted to the specified volume specific resistance may be used. Moreover, made of amorphous or crystalline glass, a material containing 3 to 50 wt.% of conductive agent such as RuO_2 may be used.

The thermet is a compound sinter of ceramic component and metal component, and, for example, a compound sinter containing TiC, TiN or the like as ceramic component, and containing Fe, Ni, Co or the like as metal component may be used.

Incidentally, when a material other than amorphous glass is used as the conductive inorganic material, its mean crystal particle size is preferred to be defined in a range of 0.8 to 10 microns. This is because it is hard to bake until dense at less than 0.8 micron, and degranulation and other defects are likely to occur when exceeding 10 microns.

As for the plates 222 and 223 for composing the head substrate 202, various materials can be used. For example, when formed of the same material as the diaphragm 221, there is no difference in thermal expansion, and breakage during use can be prevented. On the other hand, when the plates 222 and 223 are made of insulating ceramics or glass, insulation measures are necessary when placing metal or other conductive parts around the head.

The material for the piezoelectric element 203 is mainly composed of, for example, lead titanate-zirconate (PZT

series), lead magnesium niobate (PMN series), lead nickel niobate (PNN series), lead manganese niobate, and lead titanate, or their compound material.

Moreover, the driving electrode 204 is formed of at least one of, for example, gold, silver, palladium, platinum, and nickel.

In the ink jet printer head of the invention, in order to obtain a favorable response of the drive unit including the diaphragm 221, it is required to design to assure the rigidity of the drive unit by the structure of driving electrode 204 and piezoelectric element 203, but when the driving electrode 204 or the piezoelectric element 203 are extremely made thick, the deformation of the piezoelectric element 203 can be hardly transformed into the deflection of the diaphragm 221.

Under such restrictions, in order to produce a sufficient displacement in the diaphragm 221 while maintaining the rigidity of the drive unit, preferably, the Young's modulus of the conductive inorganic material for forming the diaphragm 221 should be 50 to 300 GPa, and its thickness, 5 to 50 microns. Also, the thickness of the piezoelectric element 203 is preferred to be 100 microns or less, and the thickness of the driving electrode 204 at the inside of the curvature when driving to be 5 microns or less.

When deforming the diaphragm 221, incidentally, the diaphragm 221 may be broken due to stress. To realize a free structural design of the diaphragm 221 while preventing decline of reliability due to breakage of the head, the bending strength of the conductive inorganic material for composing the diaphragm 221 is preferred to be 80 MPa or more.

A manufacturing method of the ink jet printer head of the invention is described below.

First, a same material as the diaphragm 221 mentioned above, or a green sheet made of insulating ceramics or glass is formed by doctor blade method or dipping method, portions corresponding to ejection port 206, ink chambers 201 and ink passages are blanked by using a die, sheet moldings of plates 222, 223 are fabricated, and green sheets are laminated as the diaphragm 221 from the conductive inorganic materials, and the entire structure is compressed and baked, and the head substrate 202 is formed.

Consequently, on the diaphragm 221 corresponding to each ink chamber 201, a piezoelectric material is formed as piezoelectric element 203 by thick film forming method, and is baked, and a conducive paste for driving upper electrode 204 is formed thereon by printing or other thick film forming method, or evaporating, sputtering or other thin film forming method.

As the forming method of piezoelectric element 203, green sheets may be laminated, or a thin film may be formed by CVD or other method. As the shape of the piezoelectric element 203, each end is coupled in Fig. 11, but each may be also formed independently. To form the piezoelectric element 203 into the shape shown in Fig. 11, the procedure includes a method of applying on the entire surface, masking, and removing unnecessary parts by sand blasting, or a reverse method of masking specific positions on the diaphragm 221, and applying the piezoelectric element 203 in the other positions.

As the material for the diaphragm 221 or the like, when a material containing conductive non-oxide such as thermet is used, same as mentioned above, the head substrate 202 is fabricated, and is sintered in a reducing atmosphere. Later, the piezoelectric element 203 is formed on the diaphragm 221, and the head substrate 202 made of non-oxide is baked in low temperature region so as not to be oxidized, and the driving electrode 204 baked at low temperature is formed thereon by screen printing or other thick film forming method,, or evaporating, sputtering or other thin film forming method.

To fabricate the head substrate 202, meanwhile, aside from the method mentioned above, a casting method using a resin pattern may be also employed.

In this way, in the ink jet printer head of the invention, the piezoelectric element 203 is directly disposed on the diaphragm 221 without forming lower electrode, so that the manufacturing process may be simplified.

The ink jet printer head of the invention is not limited to the structure shown in Fig. 11, but the shape and position of the ink chambers 201 and ejection port 206 may be freely changed.

Embodiment 5

By trial production of the ink jet printer head shown in Fig. 11, a driving test was conducted by varying the volume specific resistance of the material for composing the diaphragm 221.

The diaphragm 221 was formed of conductive ceramics composed of perovskite oxide having various volume specific resistance values as designated below, with the length of the portion corresponding to the ink chamber 201 of 1 mm in the longitudinal direction and 0.2 mm in the width direction, and the thickness of 15 microns. The thickness of the piezoelectric element 203 was 30 microns, the number of drive units was five, the applied voltage was 70 V, and the wave was rectangular with 1 kHz.

In the above conditions, by passing a specific current continuously to the diaphragm 221 side to establish a specific potential, a voltage was applied to the driving electrode 204 side, and the piezoelectric element 203 was driven. By

driving continuously for 5 minutes, if the temperature rise is over 10°C, the ink ejection performance is not stable, and hence it is not preferred as printer head. If the fluctuation of displacement among drive units is over 20%, it is evaluated as defective driving performance. The results are as follows.

Diaphragm volume specific resistance (Ω · cm)	Temperature rise (°C)	Driving performance
0.5×10^{-1}	3	Excellent
0.1×10^{-1}	5	Excellent
1.0×10^{-1}	7	Excellent
1.2×10^{-1}	10	Poor

In these results, a large fluctuation of displacement among drive units was noted when the volume specific resistance of the diaphragm 221 was larger than 1.0×10^{-1} Ω · cm, which is because a potential difference occurs among units when passing a current into the diaphragm 221. Besides, when the temperature rise of the diaphragm 221 is extreme, the ink viscosity is changed by heat, and the ejection characteristic varies, and the printing performance of the printer is no longer stable. By continuous driving for 5 minutes, the temperature rise of the diaphragm was 10°C or less in all samples, and considering stability of the printer in longer continuous use and driving performance of the head, the volume specific resistance of the diaphragm 221 is preferred to be in a range of 1.0×10^{-1} Ω · cm or less.

Embodiment 6

Same as above, further adding RuO_2 to the glass as the material for the diaphragm 221, the content of RuO_2 and qualification as the material for diaphragm 221 were investigated.

As a result, when the content of RuO_2 is in a range of 3 to 50 wt.%, the volume specific resistance is in a range of 10^{-1} to 10^{-2} Ω · cm, and it is found to be excellent as shown below.

RuO_2 content (wt.%)	Qualification as diaphragm
Less than 3%	Resistance is high, hence improper
3 to 50%	Appropriate
50% or over	Material strength is low, hence improper

Embodiment 7

Same as above, as the material for the diaphragm 221, a material mainly composed of ZrO_2 and containing NiO as conductive agent was used, and the content of NiO was varied, and the volume specific resistance was measured.

The results are as follows. When the NiO content was 40 wt.% or more, the volume specific resistance was 10^{-1} Ω · cm or less. On the other hand, when the NiO content exceeded 70 wt.%, the material strength dropped, and hence the content of NiO was preferred to be in a range of 40 to 70 wt.%.

NiO content (wt.%)	ZrO_2 (wt.%)	Volume specific resistance (Ω · cm)
70	30	10^{-5}
60	40	10^{-5}
50	50	10^{-6}
40	60	10^{-3}
30	70	10^{1}
20	80	10^{6}

Embodiment 8

The thickness of the diaphragm 221 and piezoelectric element 203 was changed, and the displacement of the diaphragm 221 and the maximum generated stress were determined by the finite element method. The following specimens were prepared.

Specimen A: Diaphragm 221 with longitudinal direction dimension of 1 mm, width direction of 0.2 mm, thickness of 1 to 20 microns, piezoelectric element 203 with thickness of 30 microns, applied voltage of 70 V.

Specimen B: Diaphragm 221 with longitudinal direction dimension of 3 mm, width direction of 0.5 mm, thickness of 15 to 35 microns, piezoelectric element 203 with thickness of 50 microns, applied voltage of 100 V.

Specimen C: Diaphragm 221 with longitudinal direction dimension of 5 mm, width direction of 0.7 mm, thickness of 30 to 70 microns, piezoelectric element 203 with thickness of 100 microns, applied voltage of 200 V.
In all specimens, the Young's modulus of the material for the diaphragm 221 was 150 GPa, and driving electrode 204 was not used. The results are as follows.

Specimen A (minimum allowable diaphragm displacement 0.1 micron)			
Diaphragm thickness (µm)	Diaphragm displacement (µm)	Maximum stress (MPa)	
1	0.48	153	Excessive stress
5	0.24	97	Appropriate
10	0.17	71	Appropriate
15	0.13	54	Appropriate
20	0.09	49	Insufficient displacement

Specimen B (minimum allowable diaphragm displacement 0.02 micron)			
Diaphragm thickness (µm)	Diaphragm displacement (µm)	Maximum stress (MPa)	
15	0.064	97	Appropriate
20	0.048	81	Appropriate
25	0.032	72	Appropriate
30	0.022	65	Appropriate
35	0.017	51	Insufficient displacement

Specimen C (minimum allowable diaphragm displacement 0.01 micron)			
Diaphragm thickness (µm)	Diaphragm displacement (µm)	Maximum stress (MPa)	
30	0.034	84	Appropriate
40	0.021	80	Appropriate
50	0.016	77	Appropriate
60	0.011	75	Appropriate
70	0.009	74	Insufficient displacement

In specimens A to C, as the diaphragm 221 is thinner, the displacement is larger, but the maximum stress occurring in the diaphragm 221 becomes higher, and the diaphragm 221 is easily broken. Accordingly, in order to prevent damage of the diaphragm 221 while maintaining a specific displacement, it is necessary to set the thickness properly by defining the bending strength of the material. Herein, the bending strength of the material for the diaphragm 221 was set at 80 MPa or more, and further considering the reliability of the diaphragm 221, an appropriate design of the diaphragm is defined so that the generated stress be 120 MPa or less.

In these specimens A to C, as the area of the diaphragm 221 is wider, the displacement of the diaphragm 221 required to eject a specified amount of ink becomes smaller in inverse proportion, and hence the thickness of the diaphragm 221 was determined in gradual steps depending on the area. In order to prevent damage while maintaining displacement in each shape, the thickness of the diaphragm 221 is desired to be set in a range of 5 to 50 microns.

Embodiment 9

Same as in embodiment 4, the Young's modulus of the diaphragm 221 was compared. The following specimens were prepared.

Specimen D: Diaphragm 221 with longitudinal direction dimension of 1 mm, width direction of 0.2 mm, thickness of 15 microns, piezoelectric element 203 with thickness of 30 microns, applied voltage of 70 V.

Specimen E: Diaphragm 221 with longitudinal direction dimension of 3 mm, width direction of 0.5 mm, thickness of 25 microns, piezoelectric element 203 with thickness of 50 microns, applied voltage of 100 V.

Specimen F: Diaphragm 221 with longitudinal direction dimension of 5 mm, width direction of 0.7 mm, thickness of 50 microns, piezoelectric element 203 with thickness of 100 microns, applied voltage of 200 V.
The Young's modulus of the material for the diaphragm 221 was 40, 80, 150, 200, and 250 GPa, and driving electrode 204 was not used. The results are as follows.

Specimen D (minimum allowable diaphragm displacement 0.1 micron, natural frequency 250 kHz or more)				
Young's modulus (GPa)	Diaphragm displacement (μm)	Max. stress (MPa)	Natural frequency (kHz)	
40	0.16	44	243	Improper response
80	0.15	48	330	Appropriate
100	0.14	50	360	Appropriate
150	0.13	54	421	Appropriate
200	0.12	56	472	Appropriate
250	0.11	57	499	Appropriate
300	0.10	58	511	Appropriate
320	0.09	59	514	Insufficient displacement

Specimen E (minimum allowable diaphragm displacement 0.02 micron, natural frequency 100 kHz or more)				
Young's modulus (GPa)	Diaphragm displacement (μm)	Max. stress (MPa)	Natural frequency (kHz)	
40	0.046	56	85	Improper response
80	0.041	64	159	Appropriate
100	0.038	67	191	Appropriate
150	0.032	72	251	Appropriate
200	0.027	75	308	Appropriate
250	0.023	77	343	Appropriate
300	0.020	79	371	Appropriate
320	0.018	79	384	Insufficient displacement

Specimen F (minimum allowable diaphragm displacement 0.01 micron, natural frequency 100 kHz or more)				
Young's modulus (GPa)	Diaphragm displacement (μm)	Max. stress (MPa)	Natural frequency (kHz)	
40	0.026	66	42	Improper response
80	0.022	71	81	Improper response
100	0.020	73	103	Appropriate
150	0.016	77	145	Appropriate
200	0.014	80	186	Appropriate
250	0.012	83	231	Appropriate
300	0.010	85	260	Appropriate
320	0.009	86	271	Insufficient displacement

As the natural frequency of the diaphragm 221 becomes lower, the response drops, and the number of times of ejection of ink per unit time decreases, and hence the printing speed declines. Herein, by varying the Young's modulus of the material for the diaphragm 221, the natural frequency of the diaphragm 221 was evaluated as the index of response.

By increasing the Young's modulus of the diaphragm 221, the natural frequency elevates, but the diaphragm 221 is less likely to be deformed, and a required displacement may not be obtained. In these results, it is evaluated appro-

priate when both response and displacement are established in each shape of diaphragm 221, but considering a possible correction range by design change, an appropriate range of Young's modulus of the diaphragm 221 is 50 to 300 GPa, preferably 50 to 220 GPa.

Embodiment 10

Same as the embodiment above, the thickness of the driving electrode 204 was compared. The following specimens were prepared.

Specimen G: Diaphragm 221 with longitudinal direction dimension of 1 mm, width direction of 0.2 mm, thickness of 15 microns, piezoelectric element 203 with thickness of 30 microns, applied voltage of 70 V.

Specimen H: Diaphragm 221 with longitudinal direction dimension of 3 mm, width direction of 0.5 mm, thickness of 25 microns, piezoelectric element 203 with thickness of 50 microns, applied voltage of 100 V.

Specimen I: Diaphragm 221 with longitudinal direction dimension of 5 mm, width direction of 0.7 mm, thickness of 50 microns, piezoelectric element 203 with thickness of 100 microns, applied voltage of 200 V.

The Young's modulus of the material for the diaphragm 221 was 240 GPa, the Young's modulus of the driving electrode 204 was 100 GPa, and its thickness was set at 0, 1, 2, 3, 4, 5, 6 microns. The results are as follows.

Thickness of driving electrode (μm)	Displacement of diaphragm of specimen G (μm)	Displacement of diaphragm of specimen H (μm)	Displacement of diaphragm of specimen I (μm)
0	0.13	0.032	0.016
1	0.12	0.031	0.016
2	0.11	0.029	0.015
3	0.08 (improper)	0.025	0.014
4		0.02	0.013
5		0.012 (improper)	0.011
6			0.007 (improper)

In the results, (improper) means insufficient displacement. Thus, by the rigidity of the driving electrode 204, flexural displacement of the diaphragm 221 by the piezoelectric element 203 is suppressed, and it has effects on the ink ejection performance in the head, and it is confirmed that the driving characteristic is superior when the driving electrode 204 is thinner. In particular, when the diaphragm 221 itself is thin, this effect is remarkable. Besides, as the total thickness of the diaphragm 221 including the piezoelectric element 203 and others becomes larger, the occupation ratio of thickness of the driving electrode 204 in it becomes smaller, and the effect on the displacement of the diaphragm 221 becomes smaller.

As known from these results, in order to keep an appropriate displacement of each diaphragm 221, the thickness of the driving electrode 204 is preferred to be 5 microns or less.

Embodiment 11

Same as the embodiment above, the thickness of the piezoelectric element 203 was compared. The following specimens were prepared.

Specimen J: Diaphragm 221 with longitudinal direction dimension of 1 mm, width direction of 0.2 mm, thickness of 1 to 20 microns, piezoelectric element 203 with thickness of 20, 30, 40 microns, applied voltage of 70 V.

Specimen K: Diaphragm 221 with longitudinal direction dimension of 3 mm, width direction of 0.5 mm, thickness of 15 to 35 microns, piezoelectric element 203 with thickness of 40, 50, 60 microns, applied voltage of 100 V.

Specimen L: Diaphragm 221 with longitudinal direction dimension of 5 mm, width direction of 0.7 mm, thickness of 30 to 70 microns, piezoelectric element 203 with thickness of 80, 100, 120 microns, applied voltage of 200 V.

The results are as follows.

Specimen J (minimum allowable diaphragm displacement 0.1 micron)			
Piezoelectric element thickness (μm)	Max. displacement (μm)	Max. stress (MPa)	
3	0.36	138	Excessive stress
5	0.35	116	Appropriate
15	0.23	82	Appropriate

(continued)

Specimen J (minimum allowable diaphragm displacement 0.1 micron)			
Piezoelectric element thickness (µm)	Max. displacement (µm)	Max. stress (MPa)	
24	0.16	63	Appropriate
30	0.13	54	Appropriate
36	0.07	50	Insufficient displacement

Specimen K (minimum allowable diaphragm displacement 0.02 micron)			
Piezoelectric element thickness (µm)	Max. displacement (µm)	Max. stress (MPa)	
30	0.061	107	Appropriate
40	0.043	83	Appropriate
50	0.032	72	Appropriate
60	0.024	66	Appropriate
70	0.014	62	Insufficient displacement

Specimen L (minimum allowable diaphragm displacement 0.01 micron)			
Piezoelectric element thickness (µm)	Max. displacement (µm)	Max. stress (MPa)	
70	0.033	156	Excessive stress
80	0.028	118	Appropriate
90	0.019	96	Appropriate
100	0.016	77	Appropriate
110	0.008	71	Insufficient displacement

As shown in the results, when the thickness of the piezoelectric element 203 is increased, the displacement decreases. This is because, as the thickness of the piezoelectric element 203 increases, it acts as the restrain to the displacement of the diaphragm 221, and the electric field acting on the piezoelectric element 203 (voltage/distance between electrode (that is, thickness of piezoelectric element 203)) becomes smaller, so that the displacement of the piezoelectric element 203 becomes smaller. Therefore, with the thickness of the piezoelectric element 203 increased, in order to produce a necessary displacement in the diaphragm 221, it is necessary to increase the applied voltage, which leads to increase of power consumption and heat generation in the driving circuit, and it is not preferred in design. Considering such effects, herein, it is preferred to define the thickness of the piezoelectric element 203 within 100 microns.

Thus, according to the invention, in the ink jet printer head comprising plural ink chambers, an ejection port communicating with the ink chambers, and a diaphragm for applying pressure to the ink chambers, the diaphragm is composed of conductive inorganic material, a piezoelectric element is bonded to the diaphragm, and a driving electrode is formed on the piezoelectric element, the lower electrode is not needed, the displacement of the piezoelectric element is favorably transmitted to the diaphragm, and the manufacturing process is simplified.

As a result, the head excellent in driving characteristic can be manufactured easily.

Claims

1. A member having ultrafine groove obtained bonding and integrating a partition wall composed by forming powder of ceramics, glass, silicone or the like on one side of a flat plate made of ceramics, glass, silicone or the like, by a molding die having a recess.

2. A manufacturing method of a member having ultrafine groove comprising the steps of applying a mixture of powder of ceramics, glass, silicone or the like and a binder composed of solvent and organic additive, into a molding die having a recess for partition wall, and bonding and integrating this mixture to a flat plate composed of ceramics, glass, silicone or the like.

3. An ink jet printer head comprising a diaphragm formed of a flat plate by using a member having ultrafine groove of claim 1, a piezoelectric element for driving this diaphragm, and an electrode for applying a voltage to said piezoelectric element.

4. An ink jet printer head comprising a partition wall formed of a piezoelectric material by using a member having ultrafine groove of claim 1, and an electrode for applying a voltage to said a partition wall.

5. A member for passage having plural partition walls of claim 1 arrayed in one direction, and forming a passage between said partition walls.

6. A manufacturing method of a member for passage comprising the steps of applying a mixture of powder of ceramics, glass, silicone or the like and a binder composed of solvent and organic additive, into a molding die having plural recesses for partition walls, and integrating this mixture to one side a flat plate composed of ceramics, glass, silicone or the like by arraying in one direction.

7. An ink jet printer head characterized by arraying plural partition walls of claim 1 in one direction, bonding a substrate to the upper surface of the partition walls in the member for passage forming a passage between the partition walls, thereby covering the passage, comprising a heating element in each passage, and discharging ink by producing bubbles in the ink in the passage by the heat from the heating element.

8. An ink jet printer head comprising plural ink chambers, an ejection port communicating with the ink chambers, and a diaphragm for applying a pressure to the ink chambers, wherein the diaphragm is formed of an conductive inorganic material, a piezoelectric element is bonded to this diaphragm, a driving electrode is formed on the piezoelectric element, and a driving voltage is applied between the diaphragm and driving electrode.

9. An ink jet printer head of claim 7, wherein the conductive inorganic material for composing the diaphragm has a volume specific resistance of $1 \times 10^{-1}\ \Omega \cdot \mathrm{cm}$ or less.

10. An ink jet printer head of claim 7, wherein the conductive inorganic material for composing the diaphragm is any one of conductive ceramics, and ceramics, glass and thermet containing conductive agent.

FIG.1

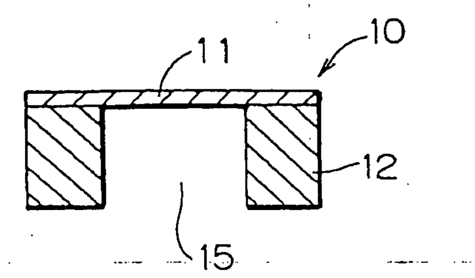

FIG.2

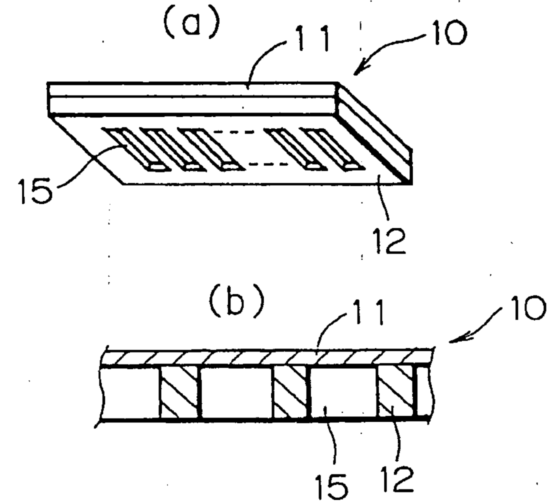

FIG.3

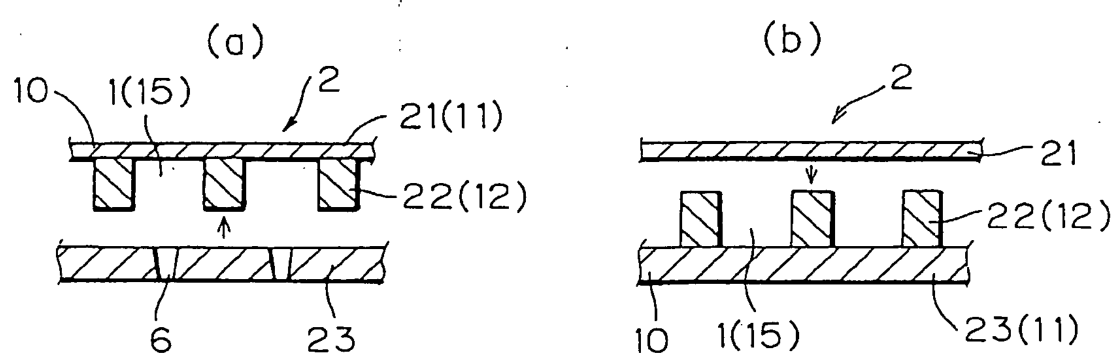

FIG.4

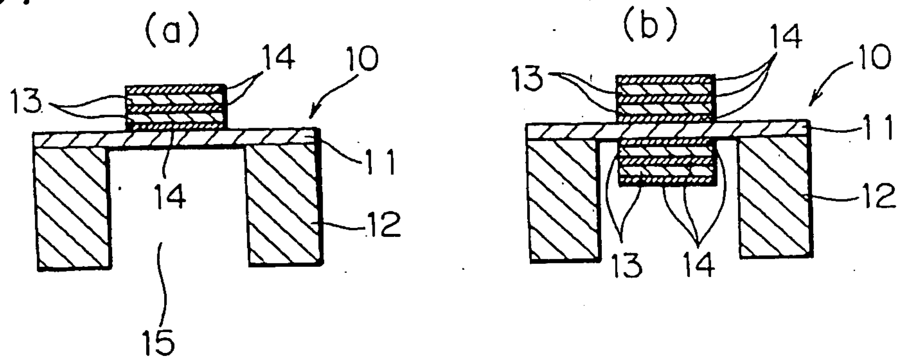
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FIG.5

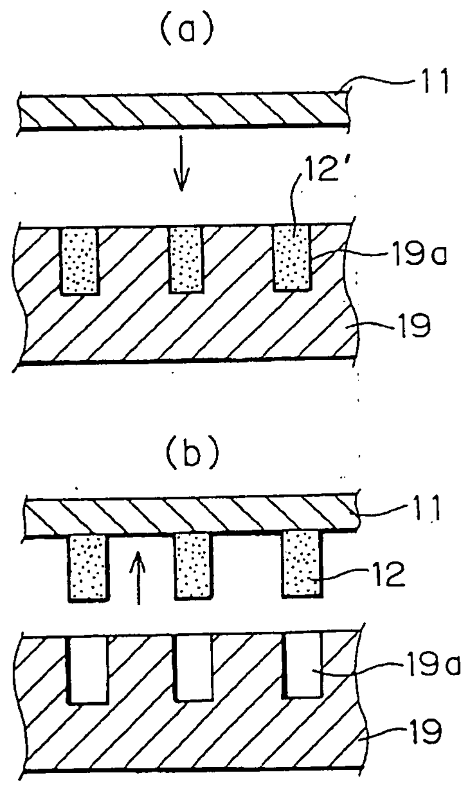
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FIG.6

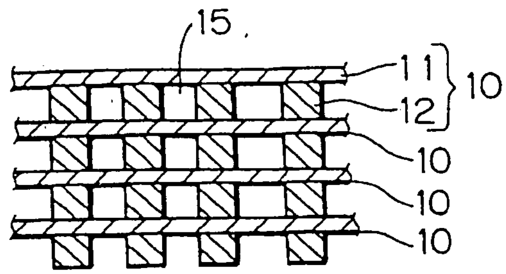

FIG.7

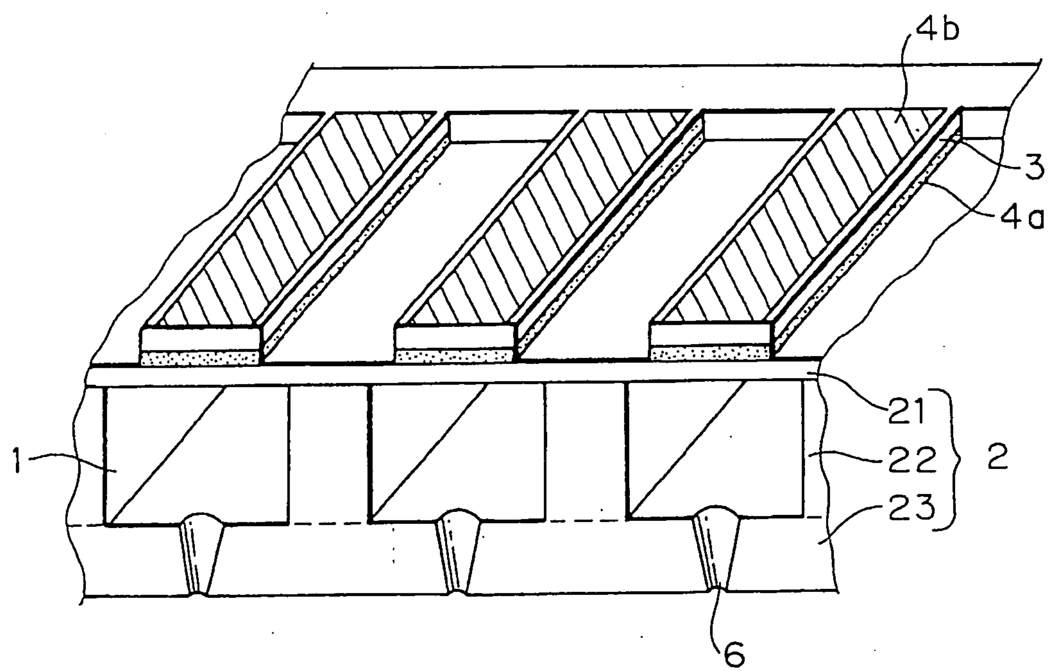

FIG.8

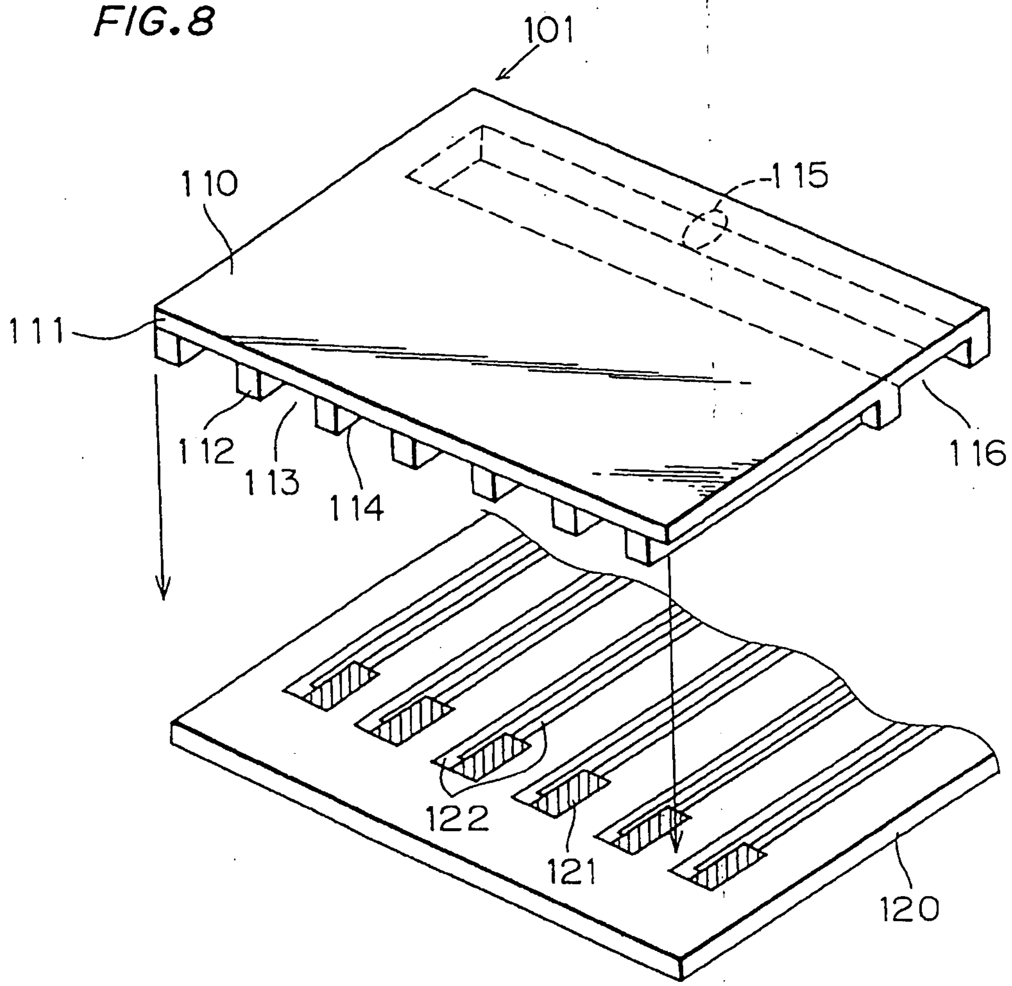
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FIG.9

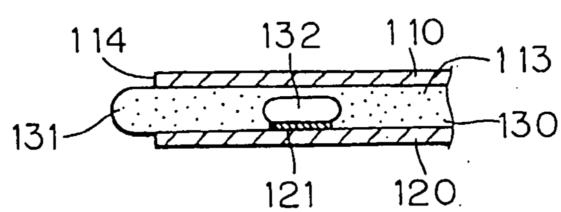
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FIG.10

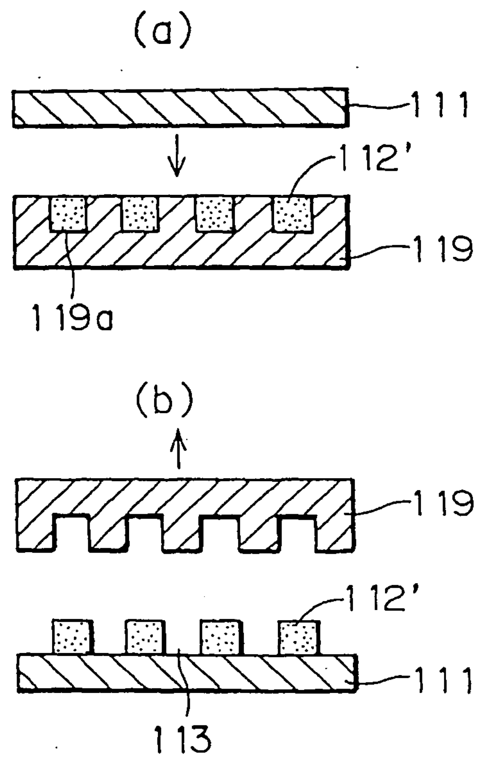

FIG.11

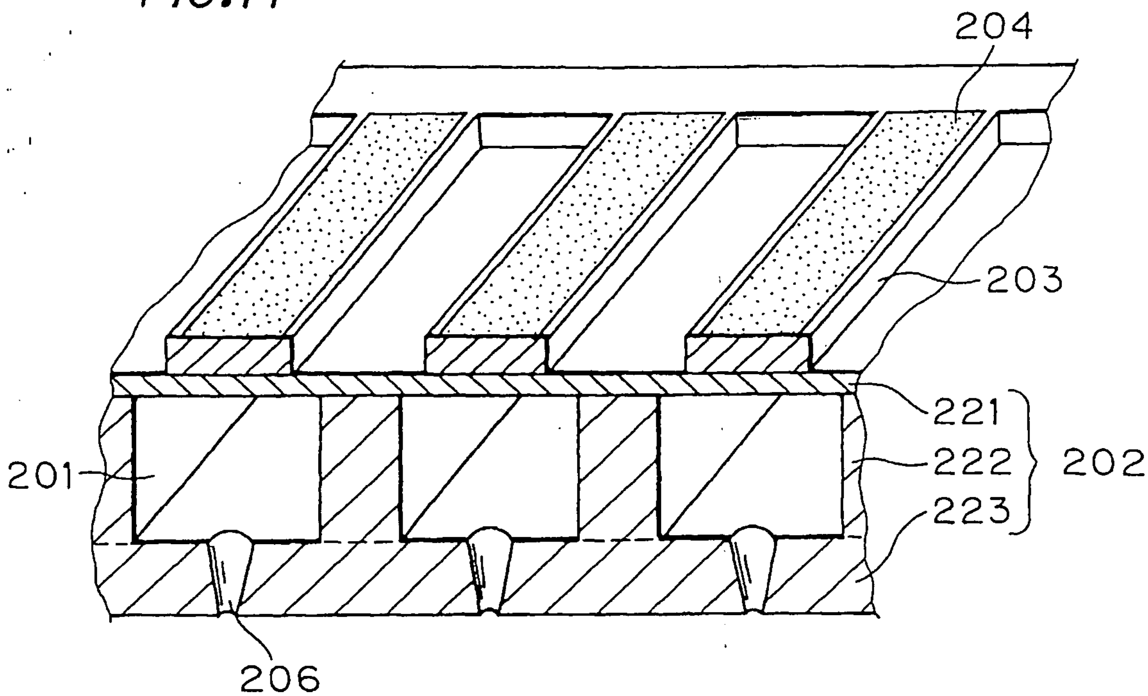
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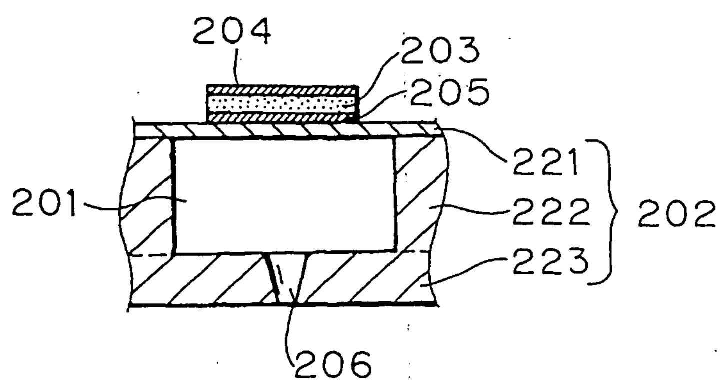
FIG.12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(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 858 894 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
13.10.1999 Bulletin 1999/41

(43) Date of publication A2:
19.08.1998 Bulletin 1998/34

(21) Application number: 98101641.3

(22) Date of filing: 30.01.1998

(51) Int Cl.6: **B41J 2/16**, B41J 2/14

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 31.01.1997 JP 1934997
09.05.1997 JP 11954697

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(54) **Member having ultrafine groove, member for passage, method of manufacturing the same, ink jet printer head using the same, and ink jet printer head**

(57) A member 10 having ultrafine groove of high density and high precision is obtained in a simple process.

On one side of a flat plate 11 made of ceramics, glass, silicone or the like, a partition wall 12 obtained by forming powder of ceramics, glass, silicone or the like by a molding die having a recess is bonded and integrated, and a member 10 having ultrafine groove is composed.

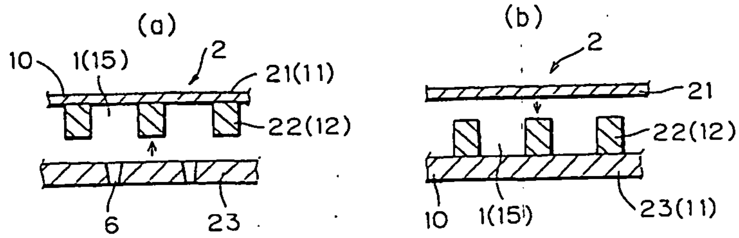
A member for passage 110 of high density and high precision is obtained in a simple process.

On one side of a flat plate 111 made of ceramics, glass, silicone or the like, a partition wall 112 obtained by forming powder of ceramics, glass, silicone or the like by a molding die having a recess is bonded and integrated, and a member for passage 110 is composed by forming a passage 113 between partition walls 112.

In an ink jet printer head comprising plural ink chambers 201, an ejection port 206 communicating with the ink chambers 201, and a diaphragm 221 for applying a pressure to the ink chambers 201, the displacement of a piezoelectric element 201 is favorably transmitted to the diaphragm 221, and the manufacturing process is simplified.

The diaphragm 221 is formed of conductive inorganic material, and a piezoelectric element 203 is bonded to the diaphragm 201, and a driving electrode 204 is formed on this piezoelectric element 203.

FIG.3



EP 0 858 894 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 98 10 1641

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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A	PATENT ABSTRACTS OF JAPAN vol. 097, no. 005, 30 May 1997 (1997-05-30) & JP 09 011518 A (TOKIN CORP;NIPPON TELEGR & TELEPH CORP <NTT>), 14 January 1997 (1997-01-14) * abstract * ---	8	
A	EP 0 671 772 A (NGK INSULATORS LTD) 13 September 1995 (1995-09-13) * the whole document * ---	8	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B41J
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 217 (M-1403), 28 April 1993 (1993-04-28) & JP 04 353464 A (BROTHER IND LTD), 8 December 1992 (1992-12-08) * abstract * ---	1-3	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 August 1999	Meulemans, J-P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EUROPEAN SEARCH REPORT

Application Number
EP 98 10 1641

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 378 (M-1161), 24 September 1991 (1991-09-24) & JP 03 151258 A (SEKISUI CHEM CO LTD), 27 June 1991 (1991-06-27) * abstract *	8,10	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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